A PROSPECTIVE STUDY ON FUNCTIONAL OUTCOME OF ADULT TYPE C DISTAL HUMERAL FRACTURES WITH BICOLUMNAR FIXATION

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M.S DEGREE IN ORTHOPAEDIC SURGERY

BRANCH II

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CERTIFICATE

This is to certify that the dissertation entitled **"A Study on Functional Outcome of Adult Type C Distal Humeral Fractures with Bicolumnar Fixation"** is a bonafide work done by **Dr.M.YUGANESWARAN** in **M.S BRANCH II ORTHOPAEDIC SURGERY** at Government Mohan Kumaramangalam Medical College, Salem-636030, to be submitted to The Tamil Nadu Dr.M.G.R Medical University, in fulfilment of the University Rules and Regulation for the award of M.S. Degree Branch II Orthopaedic Surgery, under my supervision and guidance, during the academic period from August 2008 to December 2010.

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DECLARATION

I solemnly declare that this dissertation **"A Study on Functional Outcome of Adult Type C Distal Humeral Fractures with Bicolumnar Fixation"** was prepared by me at Government Mohan Kumaramangalam Medical College and Hospital, Salem-636030 under the guidance and supervision of **Prof.R.BALACHANDRAN, M.S.Ortho., D.Ortho.,** Professor of Orthopaedic Surgery, Govt. Mohan Kumaramangalam Medical College and Hospital Salem.

This dissertation is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the University regulations for the award of the degree of M.S. Branch II Orthopaedic Surgery.

Place : Salem

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CONTENTS

ABBREVIATIONS

ROM	-Range of Movement
AVN	- Avasular Necrosis
DCP	- Dynamic compression Plate
POP	- Plaster of Paris
K wire	- Kirschner wire
FE-arc	- Flexion-Extension Arc
MEPI	- Mayo Elbow Performance Index
NSAID	- Non Steroidal anti – inflammatory drugs
FBS	- Fasting Blood Sugar
PPBS	- Post Prandial Blood Sugar
D	- Dressing
W	- Writing
Dr	- Driving
E	- Eating
T	- Toileting

INTRODUCTION

We live in a society with a growing elderly population, and young population in which extreme sports and high speed motor transportation are popular and therefore the incidence of distal humeral fractures is likely to increase. In young adults, most distal humerus fractures occur from high-energy trauma, sideswipe injuries, motor vehicle accidents, fall from height and gunshot wounds. In elderly persons with more osteoporotic bone most of these injuries occur from falls.

So improved understanding of the complex patho-anatomy of unstable distal humerus fractures in adults has prompted a global interest in more precise treatment for this diverse group of injuries. Surgeons who treat fracture of the distal humerus frequently have realized the challenges that arise related to poor bony quality, distal separation of the articular fragment from the columns of the distal humerus and fragmentation of the articular surface in one or more planes. Varying patterns of distal humeral fractures are common in adults. Malunion and nonunion are also common. Even minor irregularities of the joint surface of the elbow usually cause some loss of function.

Surgical treatment for these fractures has evolved significantly in the last 30 years. In the 1960's and 1970s, most surgeons condemned surgical treatment due to high failure rates with loss of fixation, non union and elbow stiffness.[1] In the 1970s, treatment began to shift from casting and the

“bag of bones” technique to surgical intervention with limited internal fixation. Again, results generally were poor due to lack of adequate stabilization for early motion. In the early 1980s, the **AO-ASIF** group reported good and excellent results in 27 of 39 patients with comminuted fractures of the distal humerus. These by far were the best results reported in the treatment of these difficult fractures at that time. This led to an increased enthusiasm for surgical reduction and fixation.

AIM OF STUDY

The purpose of this prospective study is to assess the functional outcome of adult comminuted supracondylar fracture with intercondylar extension by open reduction and bicolumnar fixation.

REVIEW OF LITERATURE

For thousands of years the only option for the management of distal humeral fractures was some form of external splintage. The Egyptians used palm bark and linen bandages 5000 years ago. Clay and also lime mixed with egg white were used by the ancients, but the material most commonly used over the ages has been wood.

Before the advent of Roentgenogram the treatment of distal humeral fractures were based on the correction of clinical deformity followed by the application of two short wooden splints,braces of leather and gypsum impregnated.

Plaster of Paris although introduced long ago by **A. Mattysen** (1852) in the treatment of fractures, it was not applied to distal humeral fractures for the fear of ischaemic paralysis. From 1910 onwards following the examples of **Bonier**, the plaster cast was applied with due precautions and became the decisive method of treating forearm fractures.

In the early years of 20th century internal fixation was practiced by some pioneers. The term "**osteosynthesis**" was coined by **Albin Lambotte** (1866-1955), a Belgian surgeon regarded universally as the "F**ather of modern internal and external fixation**". He devised numerous plates and screws.

In mid 19th century innovation in internal fixation methods begin to appear with some regularity.

In 1886, **Hansmann** described a percutaneously removable plate for fractures.

In 1905, **Lane, Lambotte and Scherman** developed implants and techniques of plate osteosynthesis.

In 1922, **Hitzrot**[1] quoted "Manipulative reduction usually fails and Olecranon traction exerted through the collateral ligament actually seems to increase the rotation pull upon the condyles ..... The results of collar and cuff sling followed by early joint mobilization ..... in our experience ..... have been poor".

In 1930, **Miller**[2] introduced the method of skeletal traction, i.e. olecranon or Dunlop traction for treatment. Traction was maintained approximatey for 2 weeks followed by an additional period of 2-3 weeks of immobilization in splint or cast.

In 1935, **Pauwels** defined tension band wiring techniques.

In 1936, **Danis**[3] pioneered techniques of compression osteosynthesis and defined primary union biologically.

In 1936, **Miller** described a technique and has been facilitated by the help of the image intensifier, i.e. with the elbow maintained at 90° of flexion, smooth pins (0.062 inch) were placed from each epicondyle across the fracture line in opposite cortex. The pins should be directed at a 35-45° angle to the long axis of the humeral shaft. Permanent radiograph were recommended intraoperatively to accurately control pin placement as well

as fracture reduction. Miller reported satisfactory results in 7 of 10 patients treated with k-wires and the recorded arc of motion was 47°.

In 1937, **Eastwood**[4] advocated fracture reduction with compressive manipulation of the distal articular fragments, followed by "collar and cuff" with the elbow flexed as much as possible with in limit imposed by swelling and the circulatory embarrassment. Motion in the flexed position was began at 2 weeks and at 4 weeks the recorded arc of motion reached 90°.

In 1950, **Peterson** defined basic principles of bone plating which includes careful implant handling, correct plate contour, proper screw head orientation, screw hole measurement with depth gauge, final tightening of all screws.

In 1956, **Watson Jones**[5] said "**Internal fixation is nothing more than a bone suture**" stressing the importance of immobilization after internal fixation. He said, early mobilization as an advantage of internal fixation is an over emphasis. Finger and shoulder exercises should be encouraged right from start.

In 1958, Swiss general and Orthopaedic surgeons met and discussed the causes of poor results obtained with non-operative and operative methods of fracture treatment in their country. This nucleus later developed into a group called **"ASIF (Association for the study of internal fixation) or AO (Arbeits gemein Schaft fur Osteosynthese fragen)"**. The meeting

was initiated by **Maurice E. Muller**[6] who had spent sometime with Danis and was impressed by his compression principle of fixation of fractures, the avoidance of external immobilization and the early pain free active mobilization of the injured extremity. They found that the more accurately a fracture is aligned, the less demand there will be for callus. Four principles were accepted as **"Working hypothesis"**.

- Anatomical reduction
- Rigid internal fixation
- Atraumatic technique on soft tissue as well as on the bone.
- Early pain free mobilization during the first ten post operative days.

According to **AO "Life is movement and movement is life"** should be the guiding principle of fracture care. A satisfactory internal fixation is achieved only when external splinting is superfluous and when full active pain free mobilization of muscles and joints is possible. This is the AO's main objective and is best achieved by a stable internal fixation which will last for the whole duration of bone healing.

Hicks (1961) showed a high incidence of union in fractures treated by plating with rigid fixation.

In 1964, **Brown and Morgan** reported 10 cases of intraarticular fracture treated with Collar and Cuff, they discarded additional sling support by 6 weeks after treatment. Their patients group achieved an

average range of movements of 95° but the authors noted that flexion must be gained by first 3 weeks if it has to be gained at all.

Robert Danis Jr. (1979) described the aims of internal fixation as :

- Early active mobilization
- Complete restoration of original shape of bone.
- Union of fragments without the formation of visible callus

The ideal surgical exposure for internal fixation of distal humerus fracture permits:

a) Adequate exposure
b) Extensile options
c) Soft tissue dissection
d) Dissection in the internervous plane and not across the nerves
e) All surgical alternatives to be performed through same exposure
f) Rapid rehabilitation of the involved part

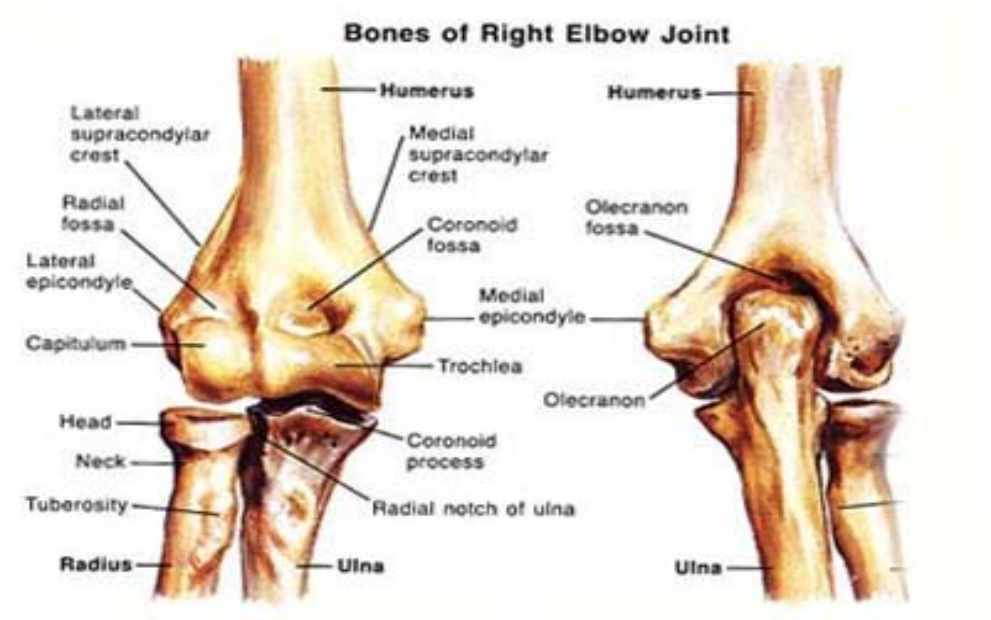
Tension band wiring

Olecranon osteotomy intended for exposure of distal humeral fracture was fixed by tension band wiring.[26]

Principles of Tension band wiring

- Distractive forces are converted to compressive forces
- The wire absorbs the tensile forces
- The bone absorbs the compression forces

ANATOMY OF DISTAL HUMERUS AND ELBOW JOINT



Picture-1

Bony Landmark – Anteroposterior View

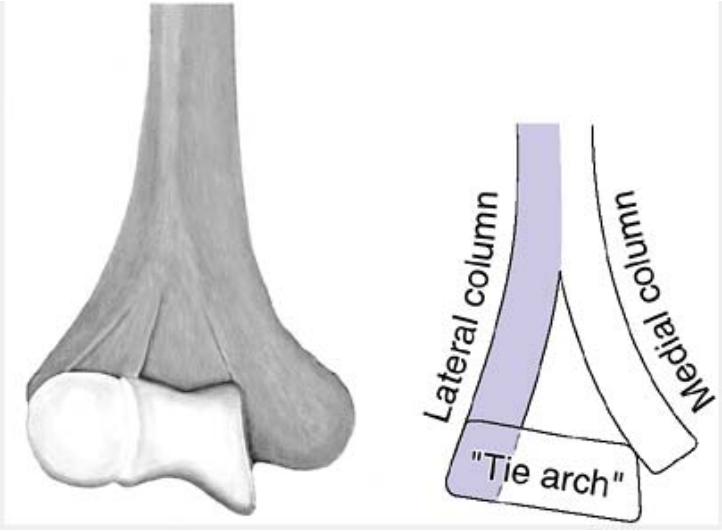
Osteology of Humerus

The humerus (arm bone), the largest bone in the upper limb, articulates with the scapula at the scapulo humeral (shoulder) joint and the radius and ulna at the elbow joint. The humerus has a proximal (upper) end, shaft, distal (lower end).

The Distal Humerus

The bone widens distally in the coronal dimension to the maximum between the medial and lateral epicondyles. When viewed from the lateral aspect, the bone narrows some what from proximal to distal in the sagittal dimension before its distal most articular segment expands and abuts

anteriorly. The slightly narrowed segment just above the articular segment corresponds to the widened portion in the coronal plane, i.e., the diverging medial & lateral columns. At their most distal point, they are joined by the 'Tie Arch', consisting of the articular segment - the trochlea and the capitellum. The capitellum itself is the most distal portion of the lateral column, whereas the trochlea is intermediate between it and the distal end of the medial column. The medially projecting and non articular medial epicondyle is the most distal portion of the medial column. It is the cephalad limit of the cubital tunnel and is closely related to the ulnar nerve. It is also the point of attachment of the ulnar collateral ligament, the strongest ligament of the elbow joint whose integrity is essential to elbow stability.[17]

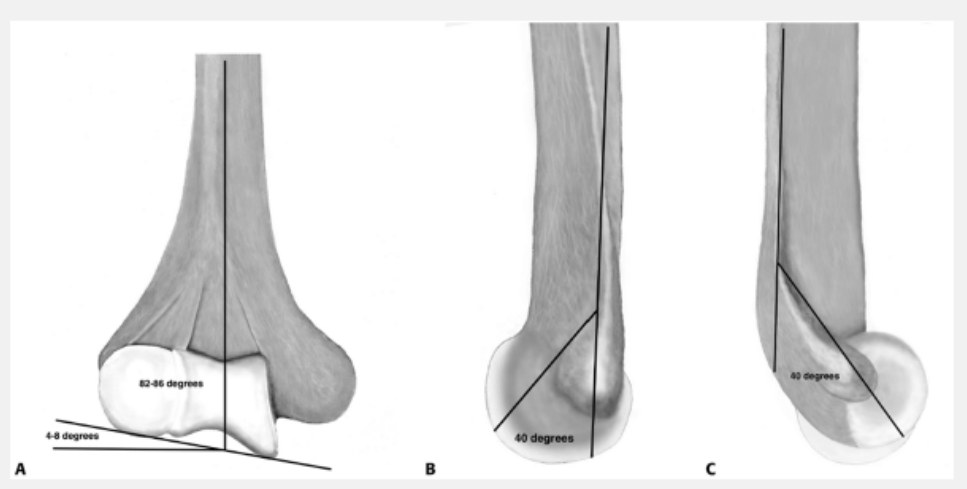


Picture-2

Tri Column Concept – Distal Humerus

The line drawn tangential to the articular surface on the AP view of the distal humerus makes an angle of between 4 and 8 degrees of valgus to the shaft axis.

The articular segment consists of the capitellum and the adjoining trochlea. The articular segment projects slightly anterior to the axis of the shaft at an angle of 40 degrees (the capitellum slightly further forward than the trochlea). It is important to note that the medial epicondyle is on the projected axis as the shaft, whereas the lateral epicondyle is projected slightly forward from the axis. When viewed from the lateral aspect, the articular surface of the capitellum is the hemispheric anterior half of the distal most part of the lateral column. This articular surface is not seen when the posterior aspect of the distal humerus is surgically exposed. The recess just cephaled to the capitellum anteriorly is the radial fossa, designed for receipt of the edge of the radial head when the elbow is fully flexed.



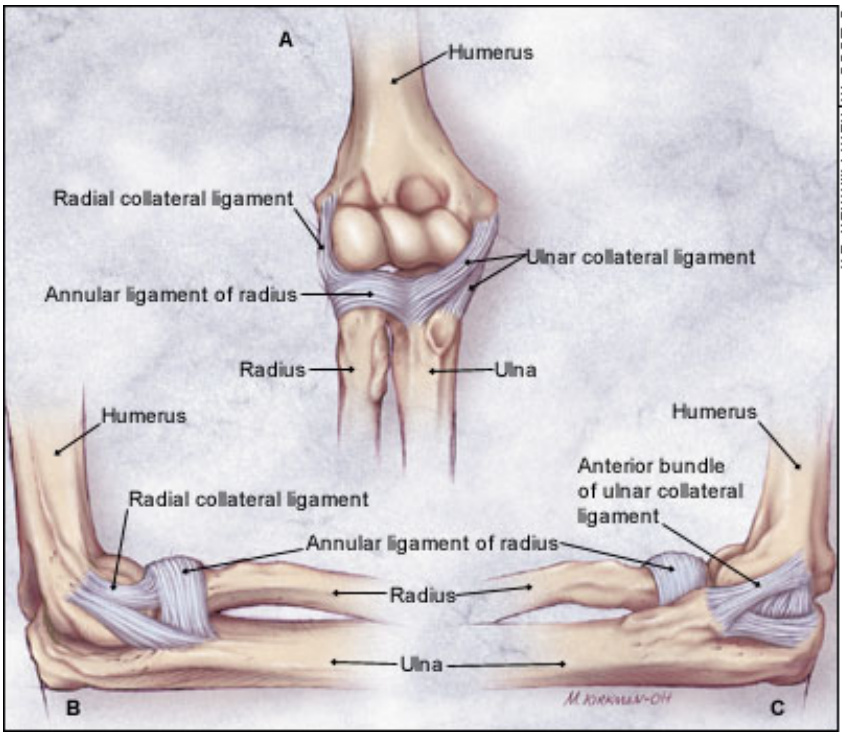
Picture-3

Condylar Relationship – Distal Humerus

The recessed and thinned bone just cephalad to the waist of the trochlea anteriorly is the coronoid fossa and its counterpart posteriorly is the olecranon fossa.

Ligamentous Anatomy:

In elbow Joint there are four main ligaments. The two primary ligaments, ulnar-collateral which is found inside the elbow and the lateral collateral found outside the elbow stabilises the humerus and the ulna. The other two ligaments are the annular and the quadrate ligament which connect the radius to the ulna.

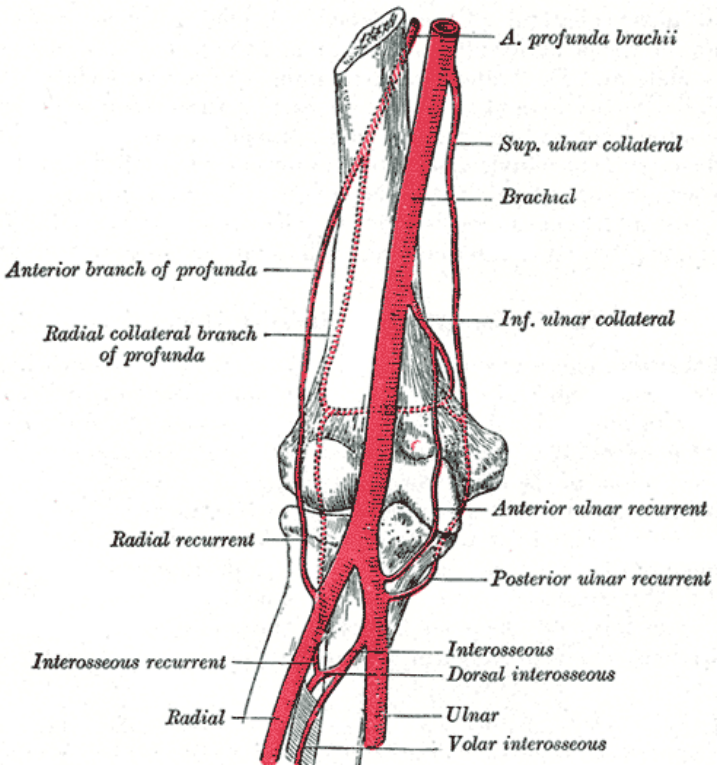


Picture-4

Ligamentous Anatomy – Distal Humerus

Blood Supply

The largest artery is brachial artery which divides at the elbow joint level into radial and ulnar artery. Anastamosis around the elbow joint provides abundant blood supply to the joint.



Picture-5

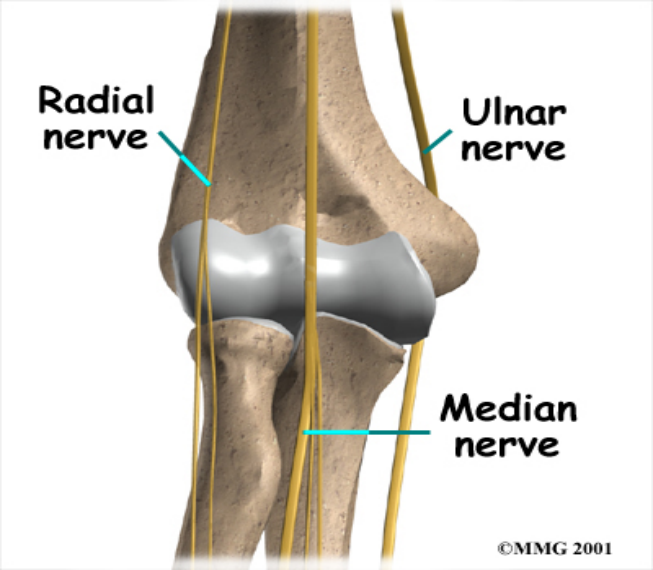
Vascular Anatomy – Distal Humerus

NERVE SUPPLY

The relationship of all three major nerves with bony elbow is essential both in surgical exposure , reduction and fixation.

- The ulnar nerve passes just behind the medial epicondyle.

- The radial nerve passes anterior to the lateral epicondyle.
- Median nerve and brachial artery passes in front of the elbow.



Picture-6

Nerve Relation – Distal Humerus

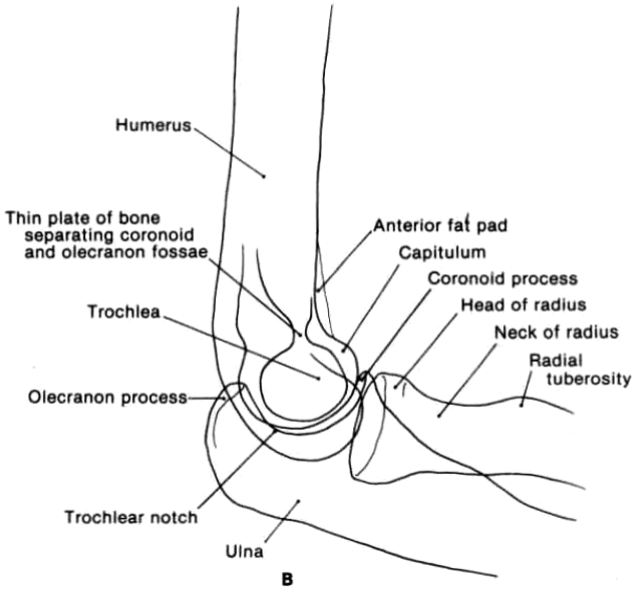
LYMPHATIC DRAINAGE:

The lymphatic drainage of the elbow begins in the hand and traverses the forearm with the accompaniment of the superficial and deep veins. The brachial lymphatics originate from antecubital nodes and arise as two or three major conduits with the brachial vessels. The brachial lymphatics terminate in the central and lateral axillary nodes. One or two epitrochlear nodes occasionally are palpable just proximal to the medial epicondyle.

Radiological Anatomy:

Picture-7

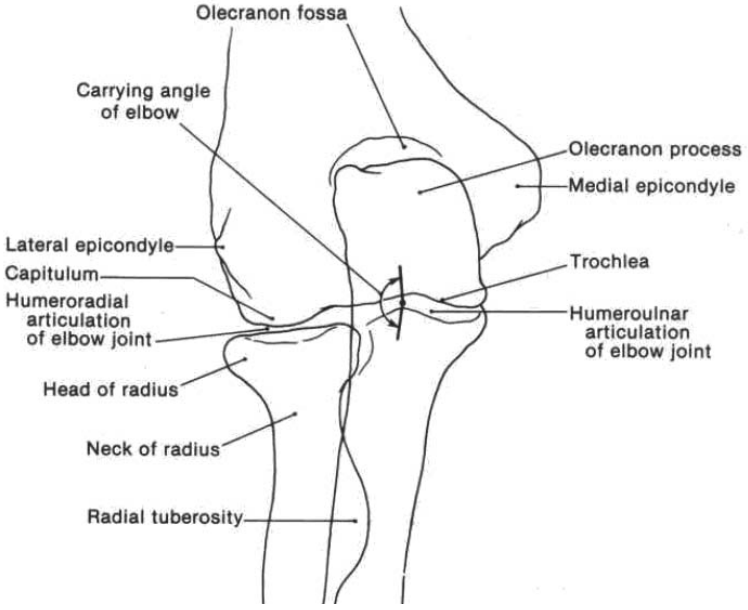
X-ray : Lateral View



Radiological Anatomy – Distal Humerus Lateral View

Picture-8

X-ray : Anteroposterior View



Radiological Anatomy – Distal Humerus Anteroposterior View

SURFACE ANATOMY

The skin overlying the elbow region is freely movable circumferentially about brachial and forearm fasciae. The contours of the biceps muscle and antecubital fossa are easily observed anteriorly and the triceps muscle and the tendon are readily palpable posteriorly. Laterally, the avascular interval between the brachioradialis and the triceps is an important palpable landmark for surgical exposures. In most individuals, the tip of the olecranon and the medial and lateral epicondyles are readily palpated and are co-linear in extension, forming an inverted triangle when the elbow is flexed to 90 degree. Laterally, the tip of the olecranon, the lateral epicondyle, and the radial head also form an equilateral triangle and provide an important landmark for joint aspiration. The flexion crease of the elbow is on a line with the medial and lateral epicondyles and thus is actually 1 to 2 cm proximal to the joint line when the elbow is extended. The inverted triangular depression on the anterior aspect of the extremity distal to the epicondyles is called the antecubital fossa. The prominent lateral supracondylar ridge separates the two surfaces into the so-called safe interval between the brachioradialis and extensor carpi radialis longus anteriorly and the triceps posteriorly. This serves as an important landmark for many lateral surgical approaches[15.]

SURGICAL ANATOMY:

- The surgical anatomy closely mirrors the functional anatomy and for stable elbow motion, the trochlea must be restored to its normal position, acting as a tie-arch between medial and lateral columns of the distal humerus. This forms the triangle of the distal humerus, which is crucial for stable elbow motion. Both columns must be securely attached to the trochlea. So every attempts must be made to restore the proper valgus and external rotation of the trochlea to allow for stability, full ROM and a normal carrying angle. The coronoid is important to elbow stability and should be reduced and fixed if displaced.
- The thin wafer of bone that separates the depth of the coronoid and olecranon fossae may be partially deficient in a small percentage of the population. These fossae are designed for the receipt of the radial head and the coronoid and olecranon processes with full flexion and extension respectively. These are important points to be kept in mind in the seating of screws on the distal lateral or medial columns for the address of distal humeral fractures. Safe screw placement assures no violation of these fossae. Impingement by a misdirected implant blocks terminal joint motion[14.]
- The medial column diverges from the humeral shaft at approximately 45 degrees, continues and ends in the medial epicondyle. As nothing articulates with the anteromedial epicondyle, the entire surface is

available for internal fixation hardware, provided the ulnar nerve to be protected and transfered anteriorly.

- The lateral column diverges from the humeral shaft at approximately 20 degrees and is largely cortical bone with a broad flat posterior surface, making it ideal for plate placement.
- At the posterior capitellum, cancellous screws must be used to avoid interrupting the anterior capitellar cartilage.
- Bio- mechanical studies have demonstrated the strongest construct of fixation of bicondylar fracture will be a direct medial plate and posterolateral plate with screws directed at 90 degree angles. This provides the varus and valgus rotational stability to the construct to allow for early range of motion.
- Proximal to the medial epicondyle, about 5 to 7 cm along the medial intermuscular septum, a supracondylar process is observed in 1 to 3 percent of individuals. A fibrous band termed the ligament of Struthers may originate from this process and attach to the medial epicondyle. When present, this spur serves as an anomalous insertion of the coracobrachialis muscle and an origin of the pronator teres muscle. Various pathologic processes have been associated with the supracondylar process, including fracture and median and ulnar nerve entrapment.

Functional Anatomy:

Biomechanics:

- Functionally, the elbow joint behaves as a constrained hinge.
- The olecranon of the ulna articulates around the trochlea of humerus. The ulnohumeral articulation is the cornerstone of osseous Stability and Mobility in the flexion - extension plane especially the coronoid process The coronoid process resists posterior subluxation in extension beyond 30° or greater, depending on the other injuries.[17] The medial facet of the coronoid is especially crucial to stability in varus stress. At the extremes of ulno-humeral motion, the coronoid or olecranon processes may 'lock' into their corresponding fossae, adding additional stability from muscular contraction and with little input from the ligaments[15.]
- The anterior band of the medial collateral ligament secures the medial side of the joint, running from an area just medial and distal to the medial epicondyle and to the sublime tubercle, slightly distal and medial to the coronoid itself. The brachialis muscle inserts more distally on the anterior surface of the proximal ulna. Fracture near the base of the coronoid may compromise these important attachments.
- The radial head also contributes to elbow stability by widening the base of support of the forearm, tensioning the posterolateral ligament and acting as an anterior buttress.

- Fracture of the coronoid process, radial head, medial epicondyle, os olecranon may be associated with elbow dislocation, making treatment more complex.
- Soft tissue structures about the eibow are responsible for as much as 40% of the resistance to valgus stress and 50% of that to varus stress in the extended position. The anterior bundle of the medial collateral ligament may provide one-third to one half of the elbow's resistance to valgus stress depending on the amount of elbow flexion and low "stability" is defined in the experimental setting.
- A large fracture of the coronoid process, a fracture of the medial epicondyle, and rupture of the medial collateral ligament may completely disrupt the medial components of the elbow. The lateral collateral ligament complex inserts onto the annular ligament. Injury to this ligament is responsible for posterolateral rotatory instability that may lead to recurrent dislocation if not properly protected during the rehabilitation.

Range of Motion:

- The ulnohumeral articulation is the cornerstone of mobility in the flexion - extension plane contributing about 0 to 135-145 degrees.
- A second range of motion occurs with the elbow joint in supination and the forearm in pronation and this ROM is allowed by the radial head

articulation with the capitellum and ulnar notch contributing about 1/3 of the total pronation- supination[15.]

Carrying Angle:

The so-called carrying angle is the angle formed by the long axes of the humerus and the ulna with the elbow fully extended. This anatomic relationship is probably more of academic and cosmetic interests than of clinical importance. The valgus angle of the humeral articulation with the long axis of the humerus and the valgus angle of the proximal ulna account for the creation of the carrying angle. In the male, the mean carrying angle is 5 to 10 degrees, and in the female, it is 10 to 15 degrees [16.]

- The trochlea also is externally rotated 3-8 degrees from a line connecting the medial and lateral epicondyles, resulting in external rotation of the arm when the elbow is flexed 90 degrees.

Epidemiology of Distal Humeral Fractures:

The overall incidence of distal humeral fractures in adults is small and comprises less than 0.5% of all fractures. Of this group, the majority will be of the C type, with the A type comprising about 10% and the B group less than 5%.[21] Bicolumn fractures are far more common distal humerus fractures accounting for remaining 85%. These fracture involve disruption of both the medial and lateral columns, thus disrupting the

humeral triangle and resulting in dissociation of the articular surface from the humeral shaft.

- Based on recent review of 73 type C fracture at a level 1 trauma center, the ratio of C3 : C2: C1 cases was 6 : 3 : 1. 31(41%) were open injuries and 43 (57%) were polytrauma victims.[18]
- Miller has made similar observations while comparing the nature of distal humeral fracture in children to that in the adult : "In children there is usually a single horizontal fracture line through the condyle whereas in the adult there is comminution with marked displacement is a rule".[18]

Mechanism of injury:

The mechanism for production of the fracture is axial load through the elbow with the joint variably flexed. When the load is applied with the elbow in hyperextension, olecranon produces the fracture, the mechanism has been accepted to be an axial load on the elbow, with the olecranon acting as a wedge splitting the medial and lateral columns of the distal humerus. The fracture pattern produced is related to degree of elbow flexion and direction and magnitude of the forces applied.

Classification of Distal Humeral fracture:

Supracondylar fracture

Numerous classification schemes have been devised to categorize adult supracondylar fracture.[18]

- In 1936, **Rich** originally classified supracondylar fracture into T and Y variations.
- In 1969, **Riseborough** and **Radin** described categories based on degree of displacement, comminution, and rotation.
- The classification of **Mehne** and **Matta** - describes the specific characteristics of bicolumn fractures and allows for better pre operative planning. The classification is as follows :
    - High T fractures
    - Low T fractures
    - Y fracture
    - H fracture
    - Medial lambda fracture
    - Lateral lambda fracture
- **Jupiter** (1985) proposed a classification system based on the concept of two column and tie-arch elbow[72,73,74`]
- As surgeons became more adopt at surgical reduction and internal fixation, the "**Arbeitsgeminschat fur Osteo Syntesfragn"** - Association for the study of Internal fixation group described a classification based on fracture pattern and degree of metapyseal and articular comminution which is essential for reconstructive procedures, not addressed in other classifications.

- The **AO** classification[75] of the fractures at this level was widely used and is the basis of the **Orthopaedic Trauma Association (OTA)**[76] Alphanumeric Classification System and the recent being used is a combination of both[77].

Type A - is Extra-Articular fracture

Type B - Partially articular fracture, that is a part of the articular segment remains in continuity with the shaft.

Type C - Complete articular fracture, but have no articular fragments remaining in continuity with the shaft.

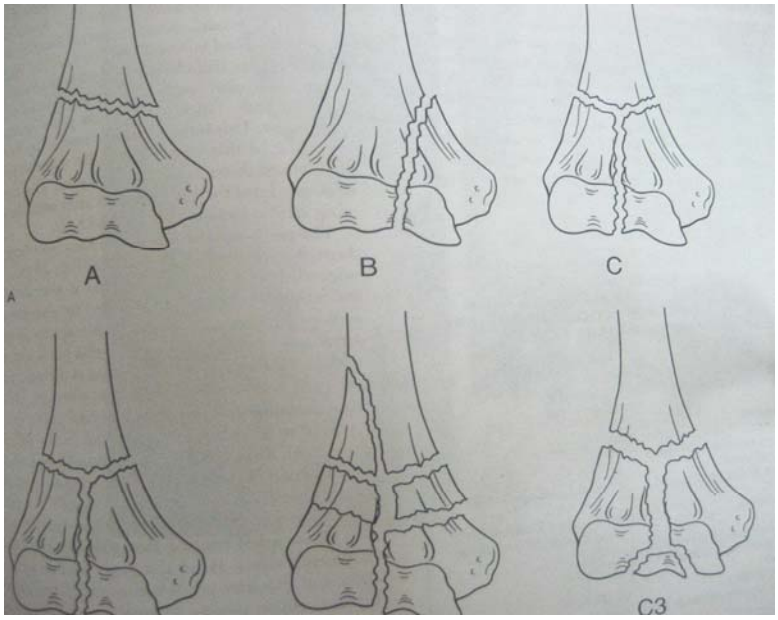
The type C fracture are again classified into three groups:

C1 - Simple articular and simple metaphyseal fractures

C2 - Articular fracture is simple, but the nonarticular supracondylar area is segmental or comminuted.

C3 - Articular segment is segmental or comminuted.

The classic T and Y fractures are type C fractures. Each of these fracture categories is further divided into numbered groups, based on fracture pattern and degree of metapyseal and articular communition. Type A fracture being easier to treat and offers a better prognosis than type B fractures.



Picture-9

A O Classification – Distal Humerus

For the purpose of this discussion, a distal humerus fracture is one whose epicenter is located in the square defined by **Muller**, whose base is the epicondyle-to-epicondyle distance on the AP X-ray view of the distal humerus.

CLINICAL FEATURES:SIGNS & SYMPTOMS

Signs and symptoms :

- Pain
- Swelling
- Tenderness

- Deformity about the distal arm and elbow
- Crepitus
- Those with displaced fracture have an obvious deformity, and attempted motion may elicit painful bony crepitus.

Diagnosis

- The diagnosis of the fracture is usually simple.
- The history of injury and presence of pain, tenderness, swelling, crepitation and angular deformity are generally confirmatory.
- A careful neurovascular assessment is imperative.
- The radiographic findings make the diagnosis obvious.

Radiological Features:

- Plain X-rays in the AP and lateral projection are all that is necessary for a diagnosis.
- These need to be good quality, (out of splint) AP and lateral X-rays obtained while maintaining gentle longitudinal traction with inclusion of the elbow joint on the film.
- Non-traction in the splint X-rays are ill-suited for accurate diagnosis for classifying the fracture and for formal preoperative planning.
- For some injuries additional information can be obtained with stress X-rays to assess associated ligamentous instability.

CHALLENGES IN MANAGEMENT OF DISTAL HUMERAL FRACTURE

1. Osteoporotic bone in the elderly
2. Complex injuries in young adults
3. Articular fragmentation

1. Osteoporotic bone in the elderly[19]

- Older adults with osteoporotic bone who fall from standing height.
- Fracture involves the articular surface and in most cases fragments are displaced.

2. Complex injuries in young adults

- Substantial energy is required to fracture the distal humerus of a young adult with strong bone.
- These higher - energy injuries are more likely to be associated with ipsilateral skeletal injuries, open wounds, neurovascular injury and injury to other limbs and organ systems.

3. Articular fragmentation

- Most fracture of the distal humerus involve the articular surface.
- The articular comminution can occur in the coronal and sagittal plane. Some fragments have little or no non-articular surface for the placement of fixation devices.

Management of Distal humeral fracture in adults

- In general displaced distal humeral fracture should be managed by open reduction and stable internal fixation. This allows for a painless elbow motion and maximizes the likelihood of full functional restoration of the brachium while the anatomically reduced and internally fixed distal humeral fracture fragments heal.
- Non-operative treatment : includes

  (1) Traction with conversion to a cast and or functional brace

  (2) Hinged Brace : When the fracture are sufficiently “sticky" at which point, controlled motion is encouraged.

  - Simple manipulation in the form of strong traction in extension,[20] followed by immobilization in as much flexion as possible (short of a right angle) compatible with stability, is applicable to the less comminuted types.
  - In unstable, grossly comminuted, lower ends of the humerus continuous vertical traction by means of a wire through the olecranon, attached to weights suspended from a pulley on a beam above the head was used. After three weeks of this traction, usually the fragments are stable enough to remove the traction and a cast is applied until union is strong enough to permit active movements."Stickiness" is judged by assessment of tenderness with gentle attempts at motion in traction as well as X-ray which

commonly occurs by 3 weeks. At this point a cast or cast brace is applied.

(3) Collar and Cuff "bag of bones" technique[21]

- Successful in elderly osteoporotic patient
- The method calls for the placement of the arm in a "collar and cuff" with as much flexion as possible. The elbow is left hanging free, allowing gravity to exert a ligamentotaxic effect. Hand and finger motion are encouraged initially and shoulder pendulum exercises are started at 10 days.
- Gradual elbow motion is started with patient comfort and resolution of swelling approximately at about 3 weeks. Healing usually occurs by 6 weeks. At which point the collar and cuff are discontinued and more intensive exercises are begun aimed at maximizing elbow extension.

(4) Elbow-Spanning external fixation

Ilizarov-Type device indicate that a hinged - type distraction external fixation allows early motion for severely comminuted supracondylar with intercondylar fracture where total reconstruction is not possible.

SURGICAL MANAGEMENT : OPEN REDUCTION AND INTERNAL FIXATION

Surgical treatment of these fracture has evolved significantly in the last 30 years.

- In the 1960s and 1970s, most surgeons condemned surgical treatment due to high failure rates with loss of fixation, non union and elbow stiffness.
- In 1970's treatment began to shift from casting and the 'bag of bones' technique to surgical intervention with limited internal fixation. Again, results generally were poor due to lack of adequate stabilization or early motion.
- In early 1980s, the **AO-ASIF** group reported good and excellent results in 27 of 39 patients with comminuted fractures of the distal humerus. These by far were the best results reported in the treatment of these difficult fracture at that time. This led to an increase enthusiasm for surgical reduction and fixation. Additional surgical approaches were developed, along with more versatile fixation hardware, leading to improved surgical results.

In 1985, **Jupiter JB** [8] in a study of 34 intercondylar fractures of the distal end of the humerus that were treated by open reduction over a ten-years period. At a mean follow up of 5-8 years, thirteen results were rated as excellent, fourteen as good, four as fair and three as poor. Complications

included post operative nerve injury in 5 patients, 3 non unions and refracture, heterotrophic bone formation and deep sepsis in one patient.

In 1987, **Gabel GT**, [10] in a prospective study, 13 patients with complex distal humeral fracture were treated by rigid internal fixation with dual buttress plate. The patients were evaluated for ROM, AVN, instability, weakness and degenerative changes. Post operative results of the patients treated according to protocol, 1 were excellent, 2 were good and one was poor, and average arc of motion of elbow range from 35^{o} to l30°.

In 1988, **G. Ackerman and JB Jupiter** studied 20 patients who had treated for a non-union of the distal end of the humerus fracture. The average time from the original fracture to the treatment of the non union was 20 months (Range 3 to 12 months). All but one had pain and instability and 15 patients (75%) had limited motion of the Elbow.

Brain S Holdsworth [11] (1990) analysed 57 adult patients at 37 months after early internal fixation for displaced fracture of distal humerus. A chevron olecranon osteotomy was used, with early active movement after fixation. Results were good / excellent in 76% with an average range of movement of 115°.

Mickae Mikee [12] in 1994, studied 13 adults of ununited intra-articular distal humeral fracture and secondary reconstruction of malunited fracture, their average age was 39-79 years. After a mean follow up of 25 months, the average age of motion was 97° with no progressive

radiographic regeneration. Ulnar nerve function improved in all cases and clinical assessment using the **Morrey** score showed 2 excellent, 8 good and 3 fair results.

Job N. Doornberg, MS David Ring [13] evaluated 104 patients at a minimum of 6 months after the latest surgery for an intra-articular fracture of the elbow, with use of three physician-based evaluation instruments **[Mayo Elbow Performance Index (MEPI), Broberg and Morrey** rating system, and **American shoulder and Elbow Surgeons Elbow Evaluation Instrument (ASES)]** and concluded pain has a very strong influence on both physician-rated and patient-rated quantitative measures of elbow function consequently. These measures may be strongly influenced by the psychosocial aspects of illness that have a strong relationship with pain, and objective measures of elbow function such as mobility may be under valued, it may be advisable to evaluate pain separately from objective measures of elbow function in physician based elbow ratings.

According to **AO** "Life is movement and movement is life"

Four principles were accepted as "Working hypothesis".

- Anatomical reduction of articular surface
- Rigid internal fixation
- Atraumatic technique on soft tissue as well as on the bone.
- Early pain free mobilization.

Principles of internal fixation in distal humeral fractures (Intra-articular fractures)

1. Reconstruction of the base of the triangle i.e., reconstruction of the trochlea, and convert into supracondylar fracture.
2. Alignment and fixation of shaft, reconstruction of medial and lateral pillars- complete restoration of triangle.

   Basic elements behind internal fixation of these fractures include the following:

   - All distal screws from one column should pass through a plate.
   - All distal screws should pass into a major fragment on the opposite column.
   - All screws should be as long as possible to engage the opposite cortex.
   - All screws should engage as many fragments as possible.
   - Screws approaching the articular surfaces and fossae should be avoided.

Implants & Instrumentation

Reconstruction plates[22]

Plates with intermediate thickness between the DCP and buttress plates have been created that have scallop-like notches in the side of the plate between the holes. These implants may be contoured in three planes to fit complex surface such as the pelvis, the distal humerus, and the

calcaneus. Because of the diminished mass of material, these plates are not as strong as comparable to DCP's.

- These plates are used with 3.5 mm cortex screws.
- Reconstruction plates have notches alongside the plate, which enables bending in three dimensions.
- Bending more than 15 degree at any one site to be avoided.
- The already low stiffness of the plate is further diminished by bending and if strong curvature is needed, considering a prebent plate is mandatory.
- Oval holes permit some self compression if the screw holes are placed over cancellous bone.
- Screws can be inserted at an angle approximately 25 degree longitudinally and 7 degree sideway.

Functional Outcome depends on:

- Age of the patient
- Severity of violence
- Associated medical & surgical comorbidities
- Stability of fixation and surgical technique
- Postoperative mobilization
- Co-operation by the patient

Complications

The most commonly observed complication after operative treatment is loss of elbow motion. Physical therapy, including active and passive ROM, as well as static progressive splinting, is useful treatment. Nonoperative treatment is usually successful only for an extrinsic elbow contracture that has been present for less than 6 months.

Anatomic reduction with stable fixation of fracture fragments, careful handling of the ulnar nerve, and adequate fixation of an olecranon osteotomy improves results of surgical treatment. Failure of fixation might be due to the result of poor bone quality, severity of comminution, although preoperative planning and poor operative technique may limit stable fixation. Careful rehabilitation progression can optimize the opposing forces of motion maintenance and fracture healing.

Nonunion rates for surgically treated distal humerus fractures range from 2-7%. Infection, bone osteoporosis, age, open fractures, multiple injuries, and inadequate fixation have been implicated as factors leading to nonunion. Symptoms include persistent pain, weakness, and instability, although most patients maintain up to an 80º arc of motion. If surgical treatment is chosen, options include revision open reduction and internal fixation, allograft reconstruction, and resection or distraction arthroplasty. Total Elbow Arthroplasty may be considered in elderly, less active patients.

- Heterotopic ossification can occur in up to 50% of cases after acute treatment of distal humerus fractures. It typically occurs in the posterolateral aspect of the elbow, from the lateral humeral condyle to the posterolateral olecranon.

- Heterotopic ossification incidence is increased with associated injuries, such as burns, head injuries, high-energy injuries, and open injuries. In these patients, prophylactic treatment should be considered. Forced passive manipulation also may increase the development of heterotopic bone formation.

Preventive measures include the use of nonsteroidal anti-inflammatory drugs (NSAIDs), low-dose radiation therapy, and continuous active ROM exercises. Most studies have looked at heterotopic ossification treatment around the hip. Regardless, the treatment of heterotopic ossification continues to be controversial. Low-dose radiation with single doses of 600-700 cGy to the elbow has been successful at preventing further progression. The concerns of neoplasm development after radiation treatment are evident.

NSAIDs have been used with success against heterotopic ossification. Indomethacin is the most commonly used drug for heterotopic ossification prevention and has been shown to decrease heterotopic ossification incidence and severity. The recommended dose is 75 mg orally 2 times per day for 3 weeks. Sucralfate at a dose of 1 g orally 4 times per day, has been recommended to prevent gastrointestinal disturbances in patients taking indomethacin.

Operative excision of heterotopic ossification is recommended 12 months after the injury, although studies have shown good results with treatment 3-6 months following injury. Declining levels of serum alkaline phosphatase and the radiographic confirmation of mature heterotopic bone can be used to help predict timing for heterotopic bone excision. However,

studies have shown no difference in serum alkaline phosphatase levels in matched populations with or without ectopic ossification. As a result, they are not routinely indicated.

The most common nerve injuries that are associated with open reduction and internal fixation of distal humerus fractures are ulnar nerve injuries. Ulnar neuropathy has been reported to occur in 7-15% of cases. The ulnar nerve, because of its proximity to the dissection, should be exposed and identified with eventual anterior transposition. Postoperative ulnar nerve dysesthesia symptoms with intact motor examination findings are common and can be closely monitored. With more proximally involved fractures, the radial nerve should be identified upon exposure. It can be damaged by retraction, plate impingement, or tissue dissection during the operation. If a change in baseline motor nerve function on postoperative examination occurs, reexploration is recommended. Brachial artery injuries have been described and are more common with extension-type elbow injuries. The brachial artery can be damaged by the sharp ends of the proximal fragment penetrating its wall.

MATERIALS AND METHODS

This study is a prospective study conducted in Govt. Mohan Kumaramangalam Medical College hospital from August 2008 to December 2010.

MATERIALS:

During the above period 23 patients with acute displaced type C fractures were treated with open reduction and internal fixation with bicolumnar plating and all the patients were followed up.

Inclusion criteria

1. Displaced adult distal humerus fracture
2. Multiple trauma patients
3. Upto Grade II Open fractures

Exclusion criteria

1. Age less than 20 years
2. Malunion & nonunion with preoperative stiffness
3. Grade III open fractures

14(61.90%) patients were male and 9(38.10%) were female and the minimum age of the patient was 26 yrs and the maximum was 59 yrs. The mechanism of injury was RTA in 16(69.60%), Direct trauma in 4(17.40%) and Fall from height in 3(13.05%).

16(66.25%) fractures involved the left elbow of which one was dominant and 7(33.75%) were right elbow all of which were dominant. Two among 23 cases were open fractures. Nine patients had associated injuries of which 4 had head injury, one with multiple rib fracture on ICD, one with fracture shaft of femur, one with both bone leg, one with fracture shaft of humerus and the last with superior and inferior pubic ramii and two had ulnar nerve neurapraxia which recovered later in two months.

Four patients had associated diabetes mellitus, one had systemic hypertension and one had both.

According to AO/ASIF fracture classification 6 were C1(26.20%), 12 were C2(52.20%), 5 were C3(21.75%).

Picture-10

Descriptive Statistics based on Sex Distribution

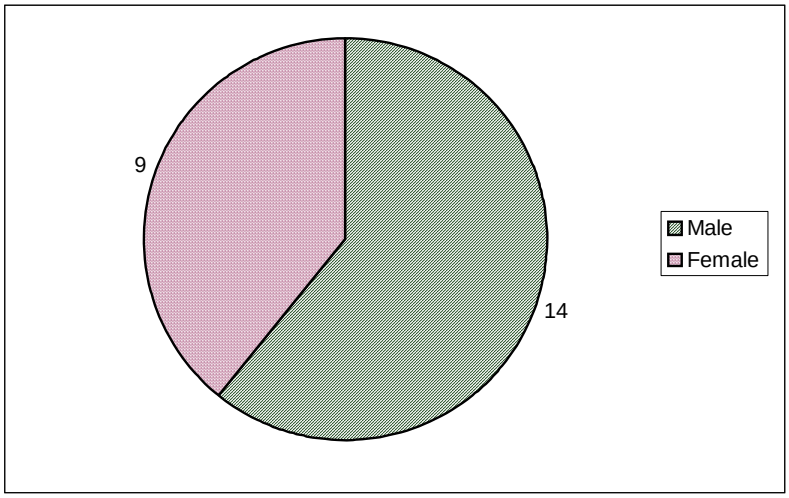


Table – 1

Descriptive Statistics based on Age Group

Age Group	Male	Female
20-30 years	2	3
31-40 years	4	3
41-50 years	5	1
51-60 years	3	2

Majority of patients fall in the 3rd and 4th decade of age

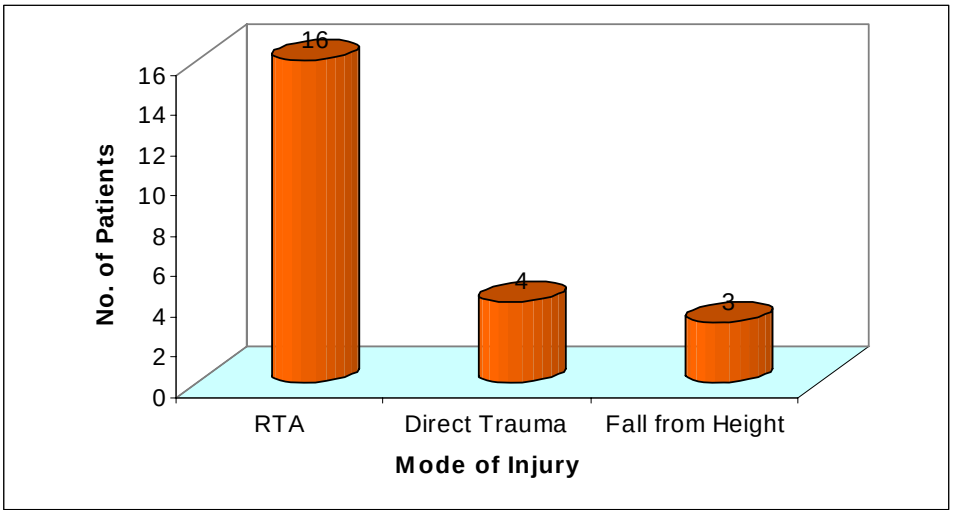
Table – 2

Descriptive Statistics based on Side Affected

Side Affected	No. of Patients
Right Side	7
Left Side	16

Picture-11

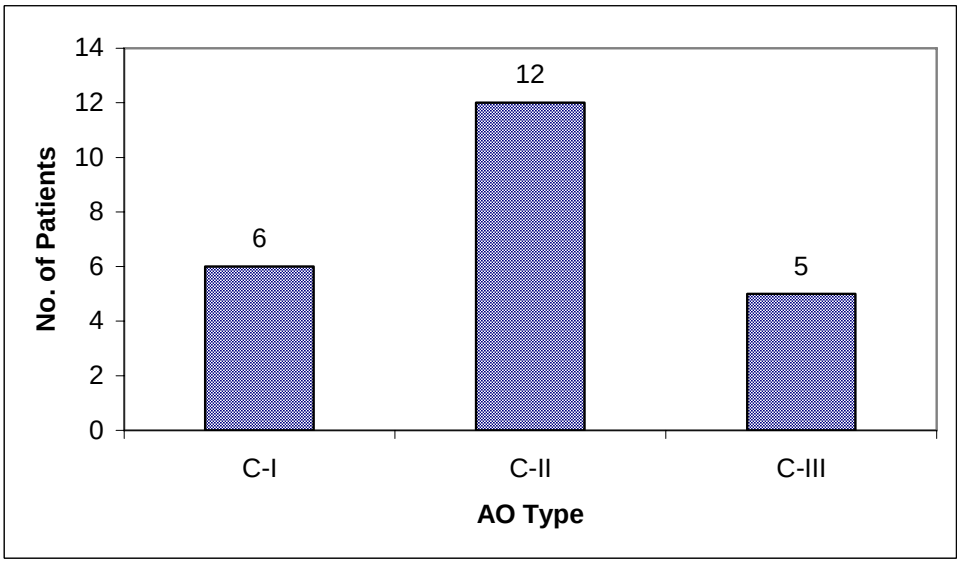
Descriptive Statistics based on Mode of Injury



Mode of injury in majority of the patients were RTA

Picture-12

Descriptive Statistics based on Type of Fracture



Majority of patients had type C2 fracture pattern.

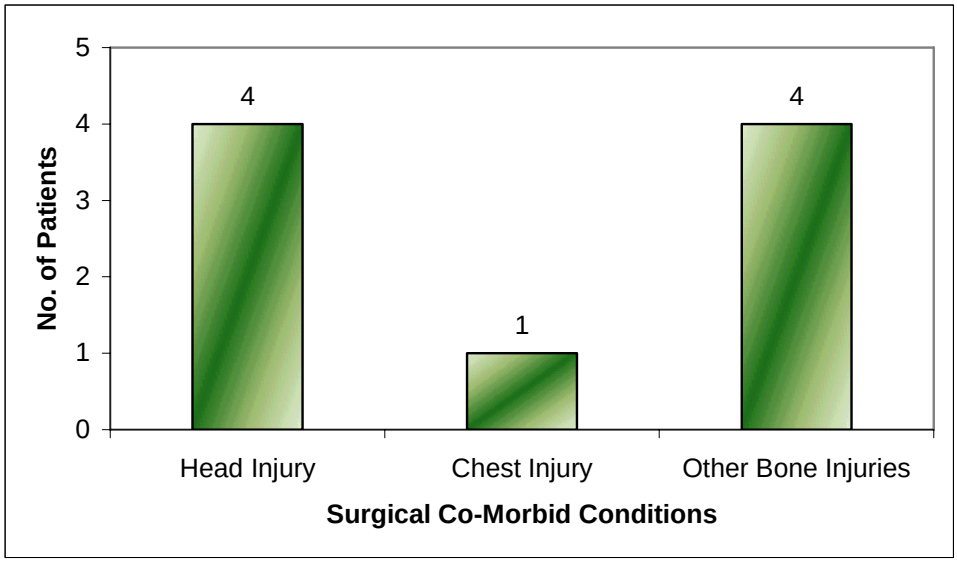
Table – 3

Descriptive Statistics based on Associated Medical Co-Morbidities

Medical Illness	No. of Patients
DM	4
HT	1
DM & HT	1

Picture - 13

Descriptive Statistics based on Associated Surgical Co-Morbidities



METHODS

PREOPERATIVE EVALUATION:

On admission, careful history was elicited from the patient or attendants to reveal the mechanism of injury. The patients were examined clinically for vitals signs, associated surgical and medical comorbidities and local examination for skin and soft tissue injuries, evidence of fracture displacements, deformity and neurovascular status .

After thorough clinical evaluation traction x-ray of the affected elbow was taken in both AP and lat view including mid third humerus and proximal third forearm to assess the geometry and configuration of fracture fragments to decide about the implants and method of fixation. The limb was immobilized in above elbow slab with positioning the forearm in supination or mid prone according to the site of fracture with sling.

The patients were taken up for surgery after routine investigations.

- Blood and urine investigations
- ECG and chest x-ray
- And when found necessary FBS and PPBS and Blood urea and creatinine were also done.

Some of our patients had associated medical problems. They were referred to the physician, many of the associated medical problems were diagnosed, they were started on treatment. Medical fitness was obtained prior surgery.

All the four head injury patients had GCS > 13/15 and were neurosurgically fit before surgery. Patients with associated tibia, femur and humerus fractures were operated within one week after distal humerus fixation.Chest injury and pubic rami fractures were treated conservatively

Patients injured limb was immobilized with POP slab initially. After treating for surgical and medical comorbidities all the patients were assessed for general or regional anaesthesia. Most of our patients were operated within 2 days with maximum period of 10 days in the elective operative list. The surgical delay was mainly to treat medical complications and head injury. The two open fracture were debrided and internally fixed on the 2^{nd} day of surgery. Prior to surgery, detailed instructions were given to each patient regarding the operative procedure and the possible complications associated with the surgical procedure and that the result of the procedure considerably depends on the patients own motivation to regain full function and the detailed written and informed consent was obtained.

- A dose of tetanus toxoid and antibiotic were give preoperatively.
- Preparation of the part was done a day before surgery and above elbow plaster of paris slab was reapplied.

TREATMENT PROTOCOL:

16 out of 23 were operated under regional block and rest were operated under general anaesthesia.11 cases were operated under tourniquet

control and 12 cases without tourniquet control.All 5 type C3 fractures and 6 out of 12 type C2 fractures were operated under tourniquet control..The patients were placed in prone position with the involved extremity hanging off the operating table in flexed position or alternatively patients were placed in the lateral position with the involved extremity hanging over a bolster. The choice of implants were decided intraoperatively through reconstruction plates, 1/3 tubular plates, 3.5mm small DCP, 4mm cancellous screws, 6.5mm cancellous screws, K wires, Stainless steel wires of all size which were kept ready . Instrument to be used were checked before hand and sterilized.

Picture-14

Array of Instruments and Implants

SURGICAL TECHNIQUE:

With the patient in prone or lateral position, patients who were operated under tourniquet control with the tourniquet applied as proximally as possible in the arm after exsanguination the tourniquet was inflated to approximately 220 mmHg. The maximum tourniquet time at an instant was 1 hour and 30 minutes in all the cases beyond which if recquired tourniquet was released, haemostasis achieved and after 20 minutes of recirculation period it was reapplied for a maximum period of 1 hour.

The incision:

"THE FRONT DOOR TO THE ELBOW IS AT THE BACK"

To achieve adequate exposure a straight posterior incision over the distal humerus, curving laterally around the olecranon and then along the upper fourth of the ulna is taken (i.e., a longitudinal incision started 10-15 cm proximal and extending 5 cm distal to the olecranon).[26]

- The ulnar nerve was identified in all cases and anterior transposition done routinely.
- The radial nerve was identified when the fracture was more proximal requiring fixation close to the spiral groove.

Olecranon osteotomy

The decision of fixing the osteotomy with 'K' wire and SS wire or cancellous screw with or without SS wire was decided preoperatively in a random manner.In case of olecranon osteotomy planned to be fixed with

cancellous screw, the olecranon is predrilled and tapped with a 6.5 mm (outer thread diameter) cancellous calibrated top to point where the dense bone adjacent to the endosteum of the ulna is engaged (The torsional resistance is increased). The point of advancement of the tap gives the surgeon an estimate of the appropriate length of screw for later fixation of the olecranon.

A thin oscillating saw is then used to make a chevron osteotomy at the level of the waist of the olecranon approximately 2cm from the tip, and it is completed with a thin, fine-pointed osteotome at the subchondral bone level. Proximal olecranon are gently dissected free from thin surrounding tissues and lifted proximally as a unit. The thin bladed instrument was used to keep the bone loss minimal.

FIXATION OF CONDYLES :

The first step is anatomic restoration of articular surface. Provisional fixation can be accomplished with a K-wire while holding the fragments with a pointed bone holding forceps. Once this is accomplished, the two condyles were fixed in a stable manner with a lag screw using 4.0mm cannulated cancellous screw. In order to facilitate this procedure it is easier to initially drill with a drill bit from inside out through the lateral condyle prior to anatomical reduction. This will ensure that the screw is in the right position. The condyles are then reduced as described above and drilled from

the lateral condyle through the trochlea and fixed with the screw making sure that the threads cross the fracture site.[26]

In type C-3 fractures with intra-articular communition it is important to maintain the correct anatomic distance between the two condyles even through there is intra articular and inter-condylar bone and cartilage loss. This should be fixed with non-lag screw so as to prevent narrowing of the inter-condylar distance, the so called Trochlear stenosis.

FIXATION OF COLUMNS:

The ensuing step in the operative procedure is anatomic reduction and restoration of condyles to the humeral shaft. This can be temporarily accomplished with the use of Kirschner wires drilled from distal to proximal through condyles in a Criss cross manner. It is necessary to maintain 40 degrees of anterior alignment of condyles relative to humeral shaft when undertaking this provisional stabilisation.

For the final fixation of the reconstituted condylar fragment to the humeral shaft two plates one on each side were used .

The columns are fixed with plates, i.e. 3.5mm reconstruction plate placed on the posterior aspect of the lateral column and a 3.5mm reconstruction plate on the medial aspect of the medial column in an orthogonal manner or one plate on the medial surface of the medial column and another plate on the lateral surface of the lateral column in a parallel

manner. Decision was made intraoperatively based on the degree of comminution of medial and lateral column. Alternatively semitubular or 1/3 tubular or 3.5mm small D.C.P were used. Inclusion of a lag screw for the articular segment in the last hole of either the medial or lateral column was desired.

It was important to ensure that none of the implants encroach upon the olecranon fossa which will result in impairment of extension. Care also taken when the transverse condylar screws were inserted to be sure they do not penetrate or burrow under the articular cartilage of the trochlea. Bone graft harvested from the same side iliaccrest in 16 cases and were kept to compensate for comminution and bone loss at the metaphyseal region.

Fixation of olecranon osteotomy:

This was done using the tension band wiring technique with cancellous screw or tension band wiring with K wire or a cancellous screw alone. If the tap does not engage and torsional resistance is low the need for tension band wiring to fix the osteotomy site was anticipated, with the screw and washer . Alternatively 'K' wires with SS wire were used.

Using the previously drilled and tapped hole in the medullary canal a transverse hole is drilled in the ulna distal to the osteotomy site approximately 4cm from the tip and a No. 20 stainless steel wire is passed

through this hole around the screw neck or the 'K' wire, underneath the triceps and tightened in a figure of eight manner.

Tourniquet removed and haemostasis achieved and wound wash given and wound closed in layers with suction drain without tension at the suture site.

POST-OPERATIVE CARE

- The patient was placed in a posterior splint (i.e. above elbow slab) with a bulky dressing and neurological status checked every 4th hourly.
- After 48 hours, the first post-operative dressing was done, drains were removed.
- The subsequent dressing was kept light and firm.
- Patients were discharged by 6th day and advised to come for review on 10th day for suture removal and POP removed from 10 th day to 15th day based on fixation and quality of bone.
- The patient was given injection cefazolin and injection Garamycin for 3 days and converted to oral antibiotics which are continued for 10 days.
- All patients were put on capsule indomethacin 25mg tds for 6 weeks
- The patient was advised at the time of discharge to continue the slab, arm pouch, oral antibiotics and shoulder mobilization.

Follow up

Patients were kept under regular followup . In patients with rigid fixation, active gentle motion of involved limb several times a day within the limits of pain was advised within 1st week postoperative period. All patients were encouraged to achieve greater than 60° of range of motion with in a month. All patients were subjected for passive physiotherapy after one month and full activity after 3 months.

Full activity was allowed at three to four months as fracture consolidation occurred.

RESULTS AND ANALYSIS

Post operatively patients were reviewed every two weeks for the first two months and monthly for the next two months, then every two months until fracture healing or full range of motion was regained.

All the fractures united radiologically with the average union time being 12 weeks (9 – 16wks) which is comparable with other studies[2,7,15]. 13 out of 23 patients had operating time less than 2 hours and the remaining more than 2 hours with the minimum being 1 hour and 30 minutes and the maximum being 3 hours, with the average being 2 hours and 15 minutes. Among 13 patients who had operating time less than 2 hours, 11 were under tourniquet control and among 10 patients who had operating time more than 2 hours all were without tourniquet control. The average blood loss was 200ml(range 100-500ml). Ulnar nerve transposition was done in all the cases. Orthogonal plating done in 14(60%), parallel plating in 9(40%). Olecranon osteotomy fixed with K wire and TBW in 15(65.25%) cases, 5(21.75%) cases with cancellous screw and TBW and 3(12%) with cancellous screw alone.

Post operatively elbow function was evaluated using physician based elbow scoring system using Mayo Elblow Performance Index (MEPI).[27]

This index divides 100 points among a physician assessment of 4 criteria.

Table - 4 : Mayo elbow performance index

Criteria	Pain	:	45 points
	Ulna Humeral Motion	:	20 points
	Stability	:	10 points
	Functional tasks (5 nos.)	:	25 points
Pain	No pain	:	45 points
	Mild	:	30 points
	Moderate	:	15 points
	Severe	:	0 points
Ulno humeral motion	Flexion-extension arc <100°	:	10 points
	Flexion-extension arc >100°	:	20 points
Stability	Stable	:	10 points
	Unstable	:	0 points
Functional task	Toileting	:	5 points
	Dressing	:	5 points
	Eating	:	5 points
	Writing	:	5 points
	Driving	:	5 points
RATING OF MAYO ELBOW PERFORMANCE SCORE			
	Excellent	:	90-100 points
	Good	:	75-89 points
	Fair	:	60-74 points
	Poor	:	Less than 60 points

According to Mayo Elbow Performance Index 17(73.95%) patients had complete pain free movements at the end of three months, 4(17.4%) had mild pain, one (4.35%) moderate and one (4.35%) had severe pain. Among 23 patients 22(95.65%)patients had stable fixation and that one(4.35%) patient having instability is mainly due to implant failure and nonunion. Regarding flexion extension arc 18(78.30%) patients had more than 100 degrees of FE arc 5(21.75%) patients had less than 100 degrees of FE arc. According to **Cassebaums** staging system 7(32.45%) patients had very good ROM, 9(39.15%) had good ROM, 4(17.40%) had fair ROM, 3(12%) had poor with the extension least being O degree for 5 patients and the maximum being 60 degree for three patients, and no limitation of pronation or supination was observed in any patient.

Regarding functional activities of daily living, 7 patients could be able to do all activities (D,E,W,T,Dr), 5 could be able to do all except toileting, 7 all except driving & toileting, 1 all except toileting & eating and 3 patients whom had poor FE arc could not be able to do anything except writing. According to most patients writing was the most easiest task and toileting was the most difficult task to do.

According to Mayo Elbow Performance Index 16(89.6%) patients had excellent outcome, 2(8.7%) had good, 2(8.7%) had fair and 3(12%) had poor outcomes.

Two (8.7%) patients had postoperative ulnar nerve injury in the form of paraesthesia which later recovered in six weeks. One (4.35%) patient had associated nonunion with implant failure in the form of broken reconstruction plate of the medial column leading to instability which later required revision surgery with one third tubular plate on posterolateral column and reconstruction plate on the medial surface and bone grafting. One (4.35%) patient had skin breakdown at cancellous screw head used to fix the osteotomy with superficial infection which healed later on with antibiotics and other (4.35%) patient had skin breakdown at K wire region used to fix the osteotomy which healed later on with secondary intention. One case of olecranon osteotomy fixed with cancellous screw alone went to nonunion which later required TBW and bone grafting.

Table-4

Descriptive Statistics based on Tourniquet time and duration of surgery

Tourniquet used	No. of Patients	Duration of Surgery < 2 hrs
YES	11	11 patients
NO	12	2 patients

11 patients who were operated under tourniquet had operating time < 2hrs

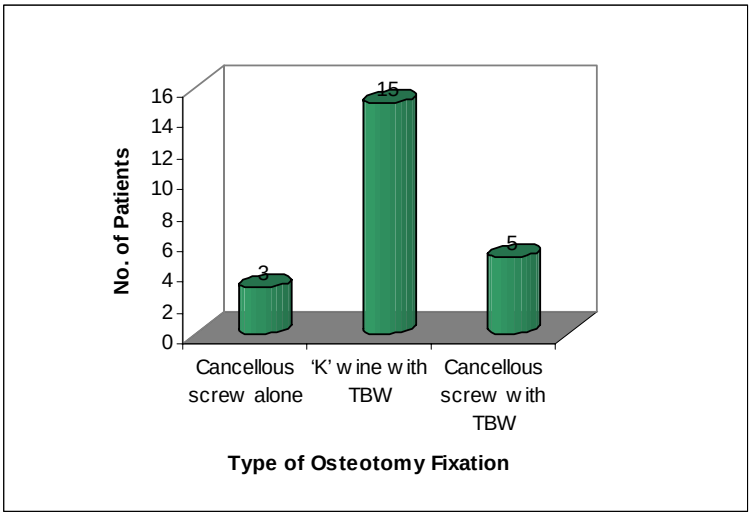
Table – 5

Descriptive Statistics based on Type of Fixation of Fracture

Type of Fracture Fixation	No. of Patients
Orthogonal	14
Parallel	9

Picture-15

Descriptive Statistics based on Type of Fixation of Osteotomy Site



There was one case of nonunion of osteotomy site among the first group

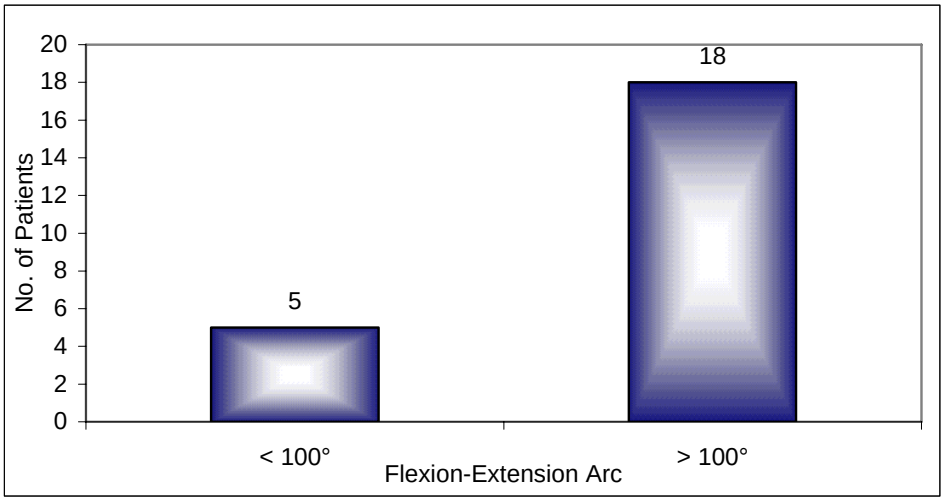
Table – 6

Descriptive Statistics based on Postoperative complications

Postoperative Complications	No. of Patients
Neuropraxia	2
Nonunion at Fracture site	1
Nonunion at Osteotomy site	1
Infection	1
Implant failure	1
Skin Breakdown at Cancellous Screw head region	1

Picture-16

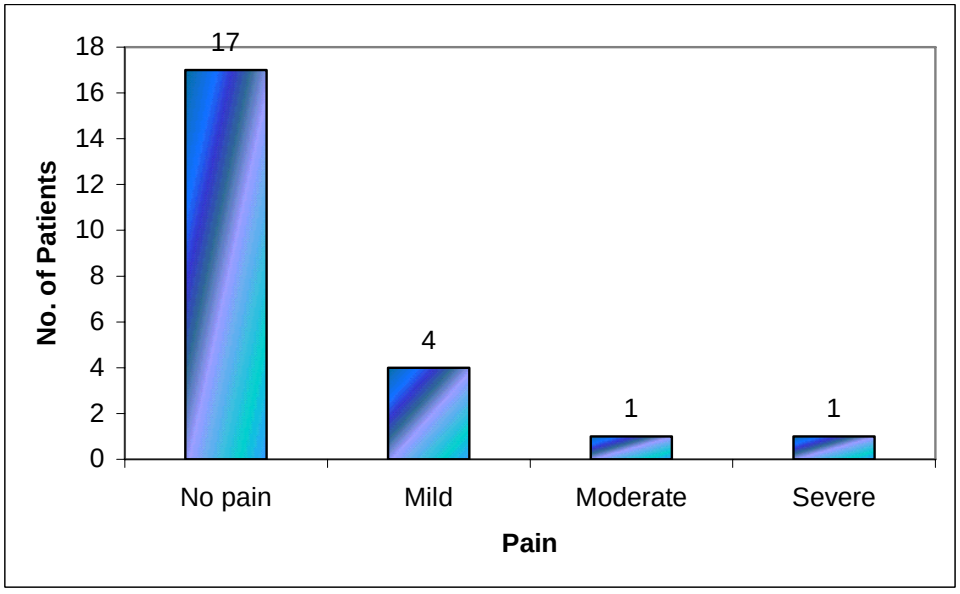
Descriptive Statistics based on Flexion – Extension Arc



Majority of our patients had satisfactory range of movements of elbow joint

Picture-17

Descriptive Statistics based on Pain



Most of our patients were either painfree or had mild pain. Only two patients suffered from disabling pain

Table – 7

Descriptive Statistics based on Stability of fixation

Stability	No. of Patients
Stable	22
Unstable	1

Table – 8

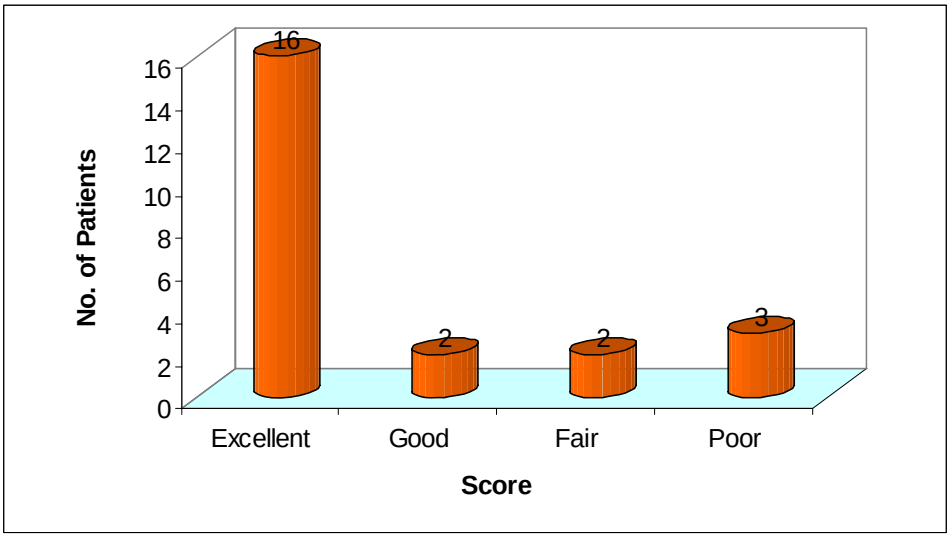
Descriptive Statistics based on Functional task

Functions	No. of Patients
D, E, W, DR, T	7
D, E, W, DR	5
D, E, W	7
D, W, DR	1
Writing	3

(D – Dressing, W – Writing, E – Eating, DR – Driving, T – Toileting)

Picture - 18

Functional Results based on MEPI Score



Majority of patients had excellent outcome in MEPI sore.

DISCUSSION

Fractures involving the distal humerus present a difficult problem in management. Intercondylar fractures of the distal humerus in adults are still more difficult to treat because of the nature of injury and the nonoperative approach to these fractures can neither ensure good restoration of the articular surface nor permit early mobilization of the elbow, key factors in achieving good function . Consensus is gradually building for surgical stabilisation of these fractures, largely as a consequence of significant advances in surgical technique and implants during the last decade ensuring a stable osteosynthesis of small articular fragments.

In our study most of our patients were males and most of them fall within in the age group of 40 years . Road traffic accident and fall from height were the most common mode of injury which were in accordance with literature except for a little younger age group in our study, which probably is because of increased incidence of road traffic accidents in third & fourth decades of life.

The complex geometry of the distal humerus requires the normal condyle–shaft angle restored in the axial, coronal and sagital planes. Intercondylar distance must be maintained in case of intercondylar comminution, to achieve an anatomic reduction with restoration of satisfactory function[36]. Several methods of fixation have been described and numerous investigators have made biomechanical comparison of those

methods and implants used[34,28,42]. Although the rigidity of the reconstruction plate and 1/3rd tubular plate is questioned[33,41] it is recommended for fixation of fractures over complex but nonweight bearing areas in most studies[10,26,28,30,33-40]. In this series we used 3.5mm reconstruction plate to fix displaced fractures of the adult distal humerus, and the results were encouraging and the number of implant failure was very minimal as it was evident by one case of implant breakage placed for the medial column.

Lateral position of the patients with the arm hanging by the side not only gives convenient access to the anaesthetist but also to the surgeon. Moreover flexion of the elbow in this position was observed to give a good view of the articular surface of the distal humerus.

Regarding the usage of tourniquet, among 13 patients who had operating time less than 2 hours 11 were under tourniquet control and among 10 patients who had operating time more than 2 hours all were without tourniquet and the operating field was clear with tourniquet which reduced the operating time in our study to an average of 1hours and 50 minutes comparable to other studies[10,26,28,33,35,37,38,40] which is less than the average time recquired without tourniquet where the average operating time was 2 hours and 30 minutes.

Regarding surgical approach triceps splitting , triceps reflecting and olecranon osteotomy though each of them has its own complications in the

form of triceps weakness, fibrosis, triceps avulsion and injury to intermuscular nerve in case of triceps splitting and triceps reflecting approaches[61], olecranon osteotomy too has got its own complications in the form of nonunion as we encountered in one of our cases and implant related complications. Other than nonunion of osteotomy site none other complications doesn't much affect the final functional outcome[60,66] the average ROM of motion in our study excluding 3 patients was 110 degrees (range 80-130) which is comparable with other studies[59,62,63,64,65,66].

As mentioned before the front door to the elbow is at the back we agree with **Jupiter et al.,** and other studies that the transolecranon approach offers excellent exposure for reconstruction of the articular surfaces particularly in type C2 and C3 fractures.

Regarding the rationale of using orthogonal and the parallel plating techniques, though both of them provides equal amount of axial and torsional resistance to strain and though both have same ROM in functional outcomes in most studies, lack of interdigitation of screws creating a fixed angle structure linking the columns together which is one of the basic objective in distal humeral fixation is lagging in case of orthogonal plating. Most of the series have demonstrated increased percentage of fixation failures with orthogonal plating than parallel plating[10,43,44,45] and in all these studies fixation failure with nonunion occurs at the supracondylar level[8.] Our study was in accordance to other studies where failure with nonunion

occurs at the metaphyseal level.It was later revised by implant removal of the lateral pillar and refixed with one third tubular plate and bonegrafting in the similar orthogonal manner. Besides type of fixation, adequate number of screws both at the condylar as well as metaphyseal level with bone grafting and stiffness of the plate and bone quality all determines the stability of fixation. To conclude regarding type of fixation orthogonal plating is preferred in case of anterior shear fracture where antero-posterior fixation provides stability to the intraarticular fractures and parallel plating in case of low humeral condyle fractures where additional stability is provided by additional screws in distal fragments.

The radiological union in our study averages 12 weeks which is comparable with other studies ranging 10-14.3 weeks[33,34,37]. Early active mobilization of the elbow has been universally accepted as a ground rule to ensure an acceptable outcome[8,23,24,25,27]. **Morrey** et al concluded that most of the activities of daily living could be accomplished with >100 degree of FE arc (30-130 degrees) which can be achieved by early postoperative mobilization[67,71,73]. It is reaffirmed by the present study ,as an excellent range of motion was achieved in all patients where early mobilization was possible due to stable internal fixation. In fact, all patients with a lesser ROM were either old patients or with a poor postoperative physiotherapy. Some loss of extension was observed in 18 of our patients which is similar to that reported by **Sanders**[26]. The age group in our series was relatively

younger, with a good bone stock and this may have been the reason for a lack of fixation failures and the higher percentage of acceptable results .**Kinik[30] and Holdsworth**[31] have also indicated that old age is no contraindication for surgical management of these fractures and the final outcome is more dependent on the quality of bone rather than chronological age of the patient. The authors are in agreement with **Sodegard[29] and Baratz** that the results are likely to be less gratifying if only elderly patients with poor bone stock are considered.

A general perusal of literature regarding internal fixation of these fractures indicates a reasonably high incidence of ulnar nerve neuropraxia[10,24,23,29,30]. We routinely transposed the ulnar nerve 5cm proximally and distally during exposure. Postoperative neurapraxia occurred in two of our patients with type C3 fractures and it was mainly due to excessive intraoperative nerve retraction in spite of neurolysis and transposition.

Though there are multiple scoring systems for assessing the functional performance of elbow in an attempt to maintain uniformity for comparison we chose **MEPI** as it shares similar characteristics with **Jupiters modification of Cassebaum's scale**[46,53] and **MEPI** was found to be more discriminating on validity studies.

According to **MEPI,** all type C1 fractures had excellent outcome, 9 out of 12 C2 fractures had excellent outcome, 2 had good outcome and

one had poor outcome and among 5 C3 fractures 2 had poor outcome, 2 had fair outcome and one had excellent outcome comparable to other studies[10,46,54,56,57,58] which concludes the influence of fracture geometry in functional outcome.

Most studies[10,46,54-58] which analysed the outcomes of adult type C fractures with dual plating by their individual criterias concluded that a stable elbow, minimal or absent pain, no deformity, a ROM between 30-120 degrees and return to near preoperative activity were all consistent with a satisfactory elbow.

All our functional performance parameters compared favourably with other studies beginning with **Jupiter** in 1985 who achieved excellent to good outcome in 78% individuals with two decades later by **Eralp, Yang** and later by **Aslam** who achieved an average of similar 80% of excellent outcome. In all the above studies the average age of the patient was 5th decades. Transolecranon approach was used in all the above series. Though functional outcomes were similar from 1980's to 2004 postoperative complications were reduced in later studies stressing the importance of routine nerve transposition and early mobilization.

Table - 9

Literature Showing Functional Outcome and Complications

Author	Year	No. of Patient	Average Age (yrs.)	Functional Outcome (%)		COMPLICATIONS (No. of Patients)			
				Excellent	Poor	Infection	Nerve Injury	Implant failure	Non union
Jupiter[72, 73]	1985	34	57	79	21	3	17	0	9
John[36]	1994	49	50	85	15	2	12	8	4
Kaushal[77]	1994	75	47	77	23	12	0	1	0
Kinik[37]	1999	46	49	69	21	0	11.1	2.2	2
Eralp[69]	2001	17	31	88	12	0	10	0	0
Yang[78]	2003	17	41	88	12	0	0	0	0
Frankle[68]	2003	12	52	67	33	1	0	3	1
Our Study	2008 - 2010	23	40	82.6	17.4	1	2	1	1

CONCLUSION

From this study we arrive at the following conclusion:

- Open reduction and internal fixation must be considered as the treatment of choice in acute type C fractures of adult distal humerus unless contraindicated.
- Use of tourniquet is beneficial in distal humerus fracture fixation in reducing the operating time.
- Transolecranon approach is to be preferred in fixing type C3 fractures, as it provides better visualization to reconstruct the joint .
- The fracture pattern greatly influences the functional outcome as we had poor score on MEPI with type C3 fractures.
- Regarding functional outcome, majority of our patients with C1 and C2 fracture pattern had good score on MEPI.

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PROFORMA

Name :

Age : Sex : IP No. :

Occupation :

Address :

Date of Admission :

Date of Surgery :

Date of Discharge :

Cause of Injury :

1. RTA
2. Fall from Height
3. Assault
4. Others

Date & Time of Injury :

First Aid given :

H/O Native Treatment : Yes / No

If Yes, type of Native Treatment :

Type of Splint :

Duration / How many Times :

H/O Medical / Surgical illness :

If Yes, type of illness & treatment :

Examination :

PR : BP :

CVS :

RS :

P/A :

CNS :

Local Examination :

1. Attitude of the Limb :
2. Compound or Closed :
3. Side affected :
4. Associated Neurovascular deficit :

Associated other bony Injuries :

Comorbid conditions : Medical / Surgical

Investigations :

Hb%, PCV, Urine routine

RBS, Urea, Creatinine

HIV, Hbs Ag.

Blood grouping & Typing

X-Ray: AP View

Lat View

Treatment :

Pre-Operative : Immobilization

Antibiotics

Surgical Management :

Time Delay since Injury :

Type of Anaesthesia :

Tourniquet used :

Implant used for humerus : Medial Piller :

Lateral Piller :

Type of Fixation : Parallel / Orthogonal

Ulnar nerve transposition : Yes / No

Implants used for Osteotomy fixation :

Duration of Surgery :

Intraoperative Antibiotics : Yes / No

Post Operative : Immediate :

Immobilization :

Complications :

Check X-Ray : Ap View

Lat View

Post Operative Follow-up Period :

Clinical Assessment :

Pain : No

Yes : Mild

Moderate

Severe

Functional Task : Eating : Yes/No

Dressing : Yes/No

Toileting : Yes/No

Writing : Yes/No

Driving : Yes/No

Elbow : FFD :

Flexion – Extension Arc :

Stability : Stable

Unstable

Complications : Infection Related :

Fracture Related :

Osteotomy Related :

Assessment of Results : Mayo Elbow performance index.

Pain : No Pain : 45

Mild : 30

Moderate : 15

Severe : 0

Functional Task : Eating : 5

Dressing : 5

Toileting : 5

Writing : 5

Driving : 5

Flexion – Extension Arc : $< 100^{o}$: 10

$> 100^{o}$: 20

Stability : Stable : 10

Unstable : 0

Mayo's Elbow Performance Score :

Excellent : 90 – 100 points

Good : 75 – 89 points

Fair : 60 – 74 points

Poor : < 60 points

MASTER CHART

S.No	Name	Age	Sex	D.O.A	D.O.S	D.O.D	Mode of Injury	Side	AO type	Associated Injuries	Tourniquet	Type of Fixation		Bone Grafting	Duration of Surgery in Hours	Post perative Complications	MEPI					Results
												Fracture	Osteotomy				Pain	FE Arc	Stability	Functional task	Total Score	
1	Namashivayam	46	M	30.7.08	2.8.08	11.8.08	RTA	R	C1		N	OR	K TBW	N	>2		N	>100	S	D,E,W,Dr	95	EXC
2	Nagammal	38	F	16.8.08	19.8.08	30.8.08	DT	L	C1		N	PL	K TBW	N	>2		N	>100	S	D,E,W,Dr	95	EXC
3	Jenista	26	F	10.9.08	15.9.08	19.11.08	RTA	R	C2	HI	N	OR	C TBW	Y	>2	INF,SBD	Sev	<100	S	W	25	POOR
4	Muralidharan	36	M	6.10.08	10.10.08	27.10.08	DT	L	C3	#SOF	Y	OR	C TBW	Y	<2		N	>100	S	D,E,W	90	EXC
5	Varadharajan	33	M	25.10.08	27.10.08	6.11.08	RTA	L	C2		N	OR	C TBW	N	>2	UNI	N	>100	S	T,D,E,W,Dr	100	EXC
6	Murali	29	M	30.10.08	1.11.08	6.11.08	DT	R	C3		Y	PL	C / C TBW	Y	<2	ONU	Mi	<100	S	W	25	POOR
7	Annamalaigd	49	M	9.11.08	18.11.08	23.11.09	RTA	R	C2	HI, CWI	Y	PL	K TBW	Y	<2		N	<100	S	D,E,W	65	FAIR
8	Kumaran	37	M	30.11.08	6.12.08	5.1.09	RTA	L	C2	HI	Y	OR	K TBW	Y	<2		N	>100	S	T,D,E,W,Dr	100	EXC
9	Vengaiyan	53	M	20.12.08	22.12.08	26.12.08	RTA	R	C1		N	OR	C TBW	N	>2		Mi	>100	S	D,W,Dr	90	EXC
10	Vanitha	29	F	1.1.09	2.1.09	10.2.09	RTA	L	C3	#SOH	Y	PL	K TBW	Y	<2	UNI	N	<1OO	S	D,E,W	80	FAIR
11	Angammal	59	F	15.1.09	20.1.09	29.9.09	RTA	L	C3	UNI	N	PL	K TBW	Y	<2		N	>100	S	D,E,W	90	EXC
12	Siraj	37	M	1.2.09	2.2.09	11.2.09	FHT	R	C2		N	OR	K TBW	Y	>2		N	>100	S	D,E,W,Dr	95	EXC
13	Paapamal	54	F	11.2.09	14.2.09	22.2.09	FHT	L	C2		Y	OR	K TBW	Y	<2		N	>100	S	D,E,W,Dr	95	EXC
14	Arumugam	29	M	2.3.09	7.3.09	15.4.09	RTA	L	C3		Y	OR	K TBW	Y	<2	NU,IF	Mi	<100	US	W	30	POOR
15	Kumarasamy	40	M	24.3.09	27.3.09	6.4.09	RTA	L	C2	#SOT, UNI	N	OR	K TBW	Y	<2		N	>100	S	D,E,W	90	EXC
16	Perumayee	32	F	2.4.09	10.4.09	20.4.09	RTA	L	C2	HI	Y	PL	K TBW	Y	<2	KBD	Mi	>100	S	D,E,W,Dr	80	GOOD
17	Punithamani	41	F	25.4.09	27.4.09	1.5.09	FHT	L	C1		N	PL	C TBW	N	>2		N	>100	S	D,E,W,T,Dr	100	EXC
18	Murugesan	43	M	5.5.09	8.5.09	15.5.09	RTA	L	C2		Y	OR	K TBW	Y	<2		N	>100	S	D,E,W,T,Dr	100	EXC
19	Kanagarani	26	F	20.5.09	25.5.09	30.5.09	RTA	R	C2		Y	OR	K TBW	Y	<2		N	>100	S	D,E,W,T,Dr	100	EXC
20	Ramasamygd	50	M	4.6.O9	8.6.09	13.6.09	RTA	L	C1		N	OR	C	N	>2		Mi	>100	S	D,E,W	75	GOOD
21	Ramakrishnan	53	M	1.7.09	3.7.09	19.7.09	RTA	L	C2	#PR	N	PL	K TBW	Y	<2		N	>100	S	D,E,W	90	EXC
22	Ganapathy	47	M	5.8.09	7.8.09	18.8.09	DT	R	C2		Y	OR	K TBW	Y	<2		N	>100	S	D,E,W,T,Dr	100	EXC
23	Malliga	34	F	16.9.09	18.9.09	25.9.09	RTA	L	C1		N	PL	C	N	>2		N	>100	S	D,E,W,T,Dr	100	EXC

M-Male; F-Female; RTA-Road Traffic Accident; DT-Direct Trauma; FHT-Fall from Height; L-Left; R-Right; Sev-Severe; PL-Parallel; OR-Orthogonal; KTBW-K wire with tension band wire; C-Cancellous screw alone;

CTBW-Cancellous screw with tension band wire; Y-Yes; N-No; Mi-Mild; Mo-Moderate; D-Dressing; E-Eating; W-Writing; T-Toileting; Dr-Driving; EXC-Excellent;

S-Stable; US-Unstable; INF-Infection; SBD- Skin breakdown; KBD-Skin breakdown with exposed 'K' wire; NU-Fracture nonunion; IF-Implant failure; ONU-Osteotomy non union; HI - Head Injury; #SOF - Fracture Shaft of femur;

#SOT - Fracture Shaft of tibia; #SOH - Fracture Shaft of humerus, #PR - Fracture Pubic rami